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About Efficiency Of Innovations: What Can Be Learned From The Innovation Union Scoreboard Index

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Abstract

A comparison of results of assessment of technical efficiency of innovativeness for 2005 and 2010 is presented in this paper. The intent is to show how capable is the Innovation Union Scoreboard (IUS) in the explanation of innovation process in transforming innovation inputs into results or innovation outputs. Critical comments regarding IUS approach are presented, along with recommended modifications. Expected gains from further studies are outlined.

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1. Introduction

Innovation constitutes a key aspect in the global business strategies. At the macroeconomic level, National Innovation Systems, defined as "network of agents and set policies and institutions that affect the introduction of technology that is new to economy" (Dahlman 1994, p.514), are critical for economic betterment (e.g. Dosi et.al., 1988; Freeman, 1995; Lundvall, 1992; Nelson, 1993, Nasierowski, 2009) and represent quite an important component of economic performance (e.g. Lööf and Heshmati, 2006). The ability of governments, businesses and individuals to identify, respond to, and especially to introduce change is the bedrock of competitive ability (e.g. Blanke et.al., 2003; Nasierowski and Arcelus, 2003; Porter, 1990; Solow, 1956). At a microeconomic level, the more practitioners' viewpoint deems participation in the global market demands and continuous improvement in technology and business processes as vital to economic prosperity, thereby providing a strong incentive to invest in innovation (Drucker, 1985, pp.133-140).

The vital role of innovation in national competitiveness is recognized by most nations. The awareness of a nation's strengths and weaknesses may allow governments to institute interventions aimed at the reinforcement its innovation record. Their tracking of innovative indicators evidences the importance for nations to recognize what aspects of their national environment push the firms within their midst to evolve, how to measure the success of the value added in innovative sectors and how to assess intellectual innovation, in terms of successful know-how. One example of efforts to track national innovation ability is the annual Innovation Union Scoreboard. IUS has been published for the first time in 2010. Until then, it had been named European Innovation Scoreboard (EIS). The notions

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EIS – IUS, and IUSI – EISI are used interchangeably in this paper. The associated composite indexes of innovativeness (IEIS; IUSI), "developed by the European Commission, under the Lisbon Strategy (e.g., that "3% of the EU's GDP (public and private combined) to be invested in R&D/innovation" by 2020) to evaluate and compare the innovation performance of its Member States" (EIS, 2005, p. 3).

The IUSI is computed as an equally weighted average of IUS indicators. The methodological base given in IUS/EIS (EIS, 2005; IUS, 2010) for the construction of the IUSI is not exempt of controversy. The IUS uses the average of the sum of inputs and outputs to innovation processes, and does not take into account weights of importance of the elements used. There are problems with 'missing data', 'outliers', lack of reliability of 'statistical data', and unanswered questions regarding credibility of results of Community Innovation Surveys (CIS) used in IUS (Nasierowski, 2008; Schibany and Streicher, 2008). Changes in the selection of IUS/EIS indicators makes longitudinal examination of innovation policies impossible, and thus, it cannot be used to assess whether or not policies relative to boosting innovations are effective or not. Despite such drawbacks, IUS forms the leading index in the area of innovativeness and a road-map in its improvement in Europe.

The purpose of this paper is to discuss methodological issues related to the IUSI, namely:
(i) what is the information content of the IUSI for each country, in the presence of a the rather ample variety of alternate composite indexes already in use;
(ii) how capable is the IUS methodology in the explanation of innovation process in transforming innovation inputs into results or innovation outputs.

To that effect, the organization of this paper is as follows. Section 2 presents a brief review of the literature, designed primarily to interpret problems related to the definition of innovation, to present the key composite indexes of economic performance that most closely resemble the IUSI in their scope and purpose, and to compare the IUSI to these indicators. Section 3 addresses issues of the efficiency with which countries transform the innovativeness inputs into innovativeness outputs via the use of Data Envelopment Analysis. The comparison of results from 2005 and 2010 is used to examine what aspects of innovativeness may be regarded common (or different), despite the changes to the IUS/EIS interpretation of innovation is presented in section 4. Results of these analyses may be used in order to extract underlying issues in identification of innovation drives. Section 5 completes the paper and outlines suggestions for further studies.

2. Literature review on innovativeness

Any discussion of innovation strategies should be strongly rooted in a clear definition of innovation. Scholarly debate on the definition of innovation has created a dizzying array of differing and sometimes contradicting definitions. Some attribute this state of affairs, at least in part to miss-definitions, or misinterpretations of what the concepts of innovation, invention, creativity, and entrepreneurship are (e.g. Rogers, 1998; Seng Tan, 2004). There seems to be an agreement on considering innovation a novelty applied to something already existing. The disagreement arises as to whether the change should be new to the market in general or to only a particular company (e.g. Välimäki, et.al., 2004). The former, denoted for the purposes of this discussion as the Frascati (FM, 2002) approach, where innovation is rooted in the level of various educational attainment statistics, R&D expenditures, and patent counts (e.g. KAM, 2006, Khan & Dernis, 2006). The latter, the Oslo (OM, 1999) approach, takes a more micro perspective and deals primarily with implementation issues to the firm. Oriented on a practitioner's viewpoint, this approach conceptualizes innovation as an application of a solution for commercial purposes.

Schumpeter (1949) defines the economic phenomenon of innovation as a process that takes an invention and develops it all the way to a marketable product or service that changes the economy. From this Frascati perspective, innovations are those solutions implemented in (or to) technologically new products/processes, subject to significant technological improvements. These can be conceptual or perceptual, should be related to opportunities, focused, and can be breathtaking simple (Drucker, 1985), as long as there is an 'appreciable element of novelty' (FM, 2002, par. 84). Such definitions form part of the Frascati manual's definition of innovativeness when stating that "technical innovation activities are all of the scientific, technological, organizational, financial and commercial steps, including investments in new knowledge, which actually, are intended to, lead to the implementation of technologically new and improved products and processes. The Frascati concept and suggested measures of change are also tightly linked to the idea of research and experimental development (R&D), being crucial to a company's survival (e.g. Jamison and Hård, 2003). The United Nations and the OECD define R&D as a "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications" (FM, 2002, par. 63).

Innovation can also be interpreted as a process specific to a period of time or a particular region, which means that the introduction of an "old technology" to a new region, with no previous exposure to the technology, is also an innovation. For example, Sajeva, et.al (2005, p. 7) define innovation as "the process leading to the adoption and diffusion of new technologies, aimed at creating new processes, products and services". While the term adoption represents the final stage of an invention, diffusion focuses on the supply of new goods and services to the customer. In this context, innovation is the mean to achieve competitiveness. Yet, there is the need to distinguish between innovation and creativity: 'creativity is the production of a novel and useful idea in any domain'; whereas 'innovation is the successful implementation of creative ideas within an organization'. Innovation is always creative, but not all creativity is innovative (Amiable, 1996; Amiable et.al., 1996). Such interpretations stem from the concept advocated by the Oslo Manual (OM, 1999, par. 131, p.51) where a minimum requirement of innovation is for a product or a process to be new (or substantially improved) for the specific company: it need not be new in global terms. Thus, innovativeness deals with implementation of new solutions in the place or for the purpose, for which these have not been used earlier. Some public institutions take a similar micro/practitioner's approach. For example, the Atlantic Canada Opportunities Agency (ACOA) recognizes the fact that innovation means different things to different people. In their terms, innovation is "a process through which economic value is extracted from knowledge through the generation, development, and implementation of ideas to produce new or improved products, processes, and services. Innovation encompasses much more than R&D or technological change. Innovation makes knowledge useful and turns it into wealth and prosperity" (ACOA, p.8).

The European Commission (EIS, 2005; IUS, 2010) takes a more comprehensive approach to the definition of innovativeness and attempts to combine both approaches. The term innovation not only describes innovation as an invention, or a technological improvement, but also includes in its scope the implementation of new ideas, processes and methods for leveraging existing ideas. However, it is worth mentioning, that there is a magnitude of composite indicators of country performance, grouped into those related to economy, environment, globalization, society, and innovation/technology (Freudenberg, 2003). References are frequently done to the Growth Competitiveness Index (GCR, 2005), the Knowledge Economy Index (KAM, 2005; Chen & Dahlman, 2005), the Human Development Index (HDR, 2005), the World Competitiveness Report Index (WCY, 2006), technological capability of countries (Archibugi & Coco, 2005, 2004; Archibugi et.al, 2009), and the UNIDO Industrial Performance Scoreboard (UNIPS) (UNIDO 2002, 2002a). Computing the Spearman correlation coefficients (e.g. Siegel and Castellan, 1988) of the country ranks obtained between any two pairs of the composite indexes mentioned above provides an overwhelming evidence in favour of the proposition that the ability of the IUSI/EISI to provide additional information over and above that of other established alternate indicators is questionable at best (Nasierowski, 2008). The p-values of these non-parametric Spearman correlation tests are all under 10^{-4}. Hence, the hypotheses that the different indexes yield different set of country rankings can be rejected. It should be pointed out that the preceding discussion does not negate the usefulness of the IUSI/EISI. It confirms the results of numerous reports (e.g. Fagerberg, 1994; McArtur & Sachs, 2002; Porter 1990, Rutten & Boekema, 2005; TEP, 1992) that highlight the importance of innovation to economic development and well-being. These results also point out that "GDP growth is influenced by so many parameters that the impact of innovation is hardly measurable" (EIS, 2005, p. 6). Hence, it is warranted to investigate, whether or not examination of such indexes can be used in the assessment of efficiency of innovation oriented efforts. The Innovation Union Index (IUS) has been used for this purpose.

3. On the efficiency of the innovation efforts in the IUS/EIS context

The concept of information efficiency is a key dimension of innovation policy. Innovation efficiency can be measured as the ability of firms to translate innovation inputs into innovation outputs (OUT/IN ratio referred to as EFX in this paper). When using the IUS/EIS methodology, each component enters the index with the same weight for all countries, regardless of whether or not the outputs and inputs themselves enter the computation equally weighted. This implies that the process of identifying the inputs and outputs required in the computation of the appropriate index of innovativeness includes the implicit assumption of all countries being equally efficient in the transformation of their inputs into their outputs. However, it is possible for two different countries to utilize totally different amounts of resources to produce an equivalent amount of outputs, without this difference being reflected in the index of innovativeness. Similarly, it is equally possible for two different countries to employ similar sets of resources and yet produce different output amounts. This leads to the issue of importance in this section, namely how to assess the technical efficiency (*EFF*) of countries in the process of transforming inputs into outputs. From a micro-economic perspective, such issue epitomizes the concept of Paretto-Koopmans efficiency (e.g. Varian, 2002), related to the ability of a country to minimize the number of inputs required to produce the maximum set of outputs possible. Within this context, a country “is fully efficient if and only if it is not possible to improve any input or output without worsening some other input or output.” (Cooper et al, 2006: 45).

To model such concept the non-parametric technique of Data Envelopment Analysis (DEA) (e.g. Coelli et al, 2005; Cooper et al, 2006) has been used, where the countries that fulfill the efficiency definition form a benchmarking frontier against which all others are evaluated. For the *EFF* formulations, the paper uses an input orientation, consistent with the belief that countries are in a better position to control the inputs than the outputs. Within this context, *EFF* relates to the minimization of the resource endowment needed to produce a set of outputs. Benchmark countries have an *EFF* of 1.00. For the others, *EFF* is measured in terms of how far the other countries must reduce their input consumption to reach the levels of their efficient counterparts.

Two crucial characteristics of a country’s production process may have an important impact on the efficiency computations. These are returns to scale (*RS*) and congestion (*CON*), two key concepts of production economics (e.g. Coelli et al, 2005; Cooper et al, 2006; Wei and Yan, 2004).

RS (Return to Scale) deals with the rate of change in the inputs utilized as compared with the rate of change in the outputs obtained. Constant *RS* (*CRS*) occur, when the rate of changes in the inputs equals that of the output. Alternatively, if rates differ from each other, there is evidence of variable returns to scale (*VRS*). Another *RS* index used below is that associated with the non-increasing returns to scale (*NRS*).

The second characteristic, congestion (CON), deals with the cost of disposing of unwanted inputs. The inefficiency arises from the fact that the presence of congestion requires the use of resources for the elimination of the undesirable inputs that would otherwise have gone to generate more outputs. “Evidence of congestion is present when reductions in one or more inputs can be associated with increases in one or more outputs - or, proceeding in reverse, when increases in one or more inputs can be associated with decreases in one or more outputs - without worsening any other input or output.” (Cooper et al, 2006). Examples of input congestion appear in Coelli et al (2005), among many others, in cases of government or union-based controls on the use of certain inputs. The literature employs the terms weak (*WD*) and strong (*SD*) disposability to denote whether evidence of congestion exists or not.

The key mathematical *DEA* structure to obtain *EFF, CON,* and *RS* is presented in Table 1. The subscript *c* denotes a specific country. The letter *x* denotes the value of a given input, identified by the subscript *i.* In a given DEA formulation, the efficiency, k_n, of the country, *n*, being evaluated is compared against that of a composite country that cannot exceed country *n* in the input usage, nor can it generate lower levels of outputs.

The level of each input and output of the composite country is the weighted average of the particular input or output of all countries in the data set. The weight for the *c-th* country, in the composite, denoted by λ_c, is a non-negative decision variable. To reflect the input-oriented definition of efficiency alluded to earlier, the objective is to minimize the efficiency index, k_n, of the country, *n*, under evaluation, i.e. to minimize the proportion of the three inputs used in the generation of the three outputs. Further details on these formulations appear in Färe et al. (1994) and in Färe and Grosskopf (2000a), among many others.

For the purposes of this paper, *VRS* (variable returns to scale) and *CON* represent two sources of technical inefficiency that may be removed from the *EFF* factor to obtain a residual, denoted by Pure Technical Efficiency (*PTE)* that better relates to the country’s resource utilization policies in the development of the innovativeness outputs. Our procedure to isolate *CON* and *RS* from *EFF* follows Färe et al (1994). All elements can take on values between 0 and 1. If *EFF*=1, so are the three components of *EFF*, namely, *RS, CON* and *PTE,* thereby resulting in the country being effective, i.e. its productive process operates under constant returns to scale and exhibits no evidence of congestion i.e. it operates under strong disposability. Any deviations from 1 suggest the presence of inefficiency. Some applications of this type of decomposition appear in Nasierowski and Arcelus (2003) and Arcelus et.al. (2006).

Table 1. The mathematical decomposition of DEA used in the paper.

For all formulations --- minimize k_n

$$\sum^{C} \lambda_c y_{co} \geq y_{on}, \quad o = 1,\ldots,I; \quad \lambda_c \geq 0, \; c = 1,\ldots,I \qquad (1)$$

c=1

For strong disposability $\sum_{c=1}^{C} \lambda_c x_{ci} \le k_n x_{in}$, i =1,.,I (2)

For weak disposability $\sum_{c=1}^{C} \lambda_c x_c = k_n x_{in}$, i = 1,…,I (3)

For VRC $\sum_{c=1}^{C} \lambda_c = 1$ (4)

For NRC $\sum_{c=1}^{C} \lambda_c \ge 1$ (5)

Efficiency Decomposition

EFF= k_n (CRS, SD) = (CON) * (RS) * (PTE) (6)

RS = k_n (CRS, SD) / k_n (VRS, SD) (7)

CON = k_n (VRS, SD) / k_n (VRS, WD) (8)

PTE = k_n (VRS, WD) (9)

Decreasing returns (DRS) if RS < 1 and k_n (NRS, SD) > k_n (CRS, SD) (10)

Increasing returns (IRS) if RS < 1 and k_n (NRS, SD) = k_n (CRS, SD) (11)

Constant returns (CRS) if RS = 1 (12)

Sources: Nasierowski (2010), Nasierowski & Arcelus (2003), Färe et al. (1994) and Färe and Grosskopf (2000a)

The efficiency decomposition given starts with the comparison between the efficiency measures under *CRS* (constant returns to scale) relative to those under *VRS.* Then, a country is scale efficient if *RS*, the ratio of these two efficiencies, equals 1. Similarly, *CON* measure deviations away from strong disposability, by calculating the ratio of the efficiency under *VRS* and weak disposability or *WD* to the efficiency under *VRS* and *SD*. If the ratio equals 1, no evidence of congestion exists and the country is operating under the strong disposability assumption. The third component, *PTE,* is the residual efficiency relative to a production technology under *VRS* and *WD*. Then, the product of the three terms of the decomposition yields *EFF.* Färe and Grosskopf (2000a) present a summary description of this decomposition.

4. Empirical results and their interpretation

All the efficiency empirical results have been obtained through the use of OnFront (Färe and Grosskopf 2000b). The technical efficiency indices, under CRS and SD appear in the EFF column of Table 2. The ALL column suggest that the average country in our data base has an efficiency index under CRS and SD of EFF'05=0.60 for 2005; and EFF'10= 0.86 for 2010, which implies that, to be efficient, the average country should cut down by up to 40% in 2005; and up to 1% in 2010, the volume of inputs utilized for the generation of the outputs and still produce the same level of outputs. This observation indicates that the technical efficiency of innovations has improved? (obviously under the assumption, that interpretation of innovativeness in 2005 and 2010 are similar, which is a questionable assumption).

Part of that inefficiency is due to scale (RS'05=0.78, RS'10 =0.90) and congestion (CON'05 = 0.8 ; CON'10 = 0.93) problems, leaving a rather meagre 0.09.% in 2005; and 0.01% in 2010, to be attributed to pure technical efficiency. Further, the results indicate the average country's technological base is operating on the basis of decreasing returns to scale: 20 countries in 2005, and 13 countries in 2010. Further, from an examination of those countries operating under a DRS technology, it is clear that their inefficiency (EFF=0.55) is mostly scale related (RS=0.71), with a congestion of CON=0.81), thereby leading to an efficient PTE of 0.84, for 2005. For 2010 these numbers are EFF =0.75; RS=0.92; CON = 0.84; PTE=0.98. This observation may suggest that generally, innovation performance within EU has improved. A testable proposition of this state of affairs is that these countries are largely the heaviest investors in innovation over time and that, at present, are at the decreasing end of their returns on any new investment. CRT countries appear to have some a small congestion problems (CON=0.95 in 2005, and CON=0.84) in 2010; otherwise, they are highly efficient (PTE=1) in their allocation of resources. Finally, IRS countries, arguably at the other side of the investment scale, have a much lower, and deteriorating EFF index (EFF=0.76 in 2005, and EFF = 0.66 in 2010), due almost equally to scale and congestion problems, they still exhibit excellent technical inefficiencies (PTE=1.00.), not due to either congestion or scale.

These observations leave us with one unexplained item: why has indicators of congestion deteriorated between 2005 and 2010, and why has it changed from the trend viewpoint. This may be explained on the basis of change in the selection of indicators used to "measure" innovativeness in 2005 and 2010 – however, such a conclusion cannot be confirmed based on the data available. Furthermore, some more observations are worth mentioning.

Rankings of countries according to EISI for 2005 and IUSI for 2010 are statistically similar. The same is true when efficiency of countries is calculated based on output/input ratio. This may indicate that the traditional (simplistic) (parametric) assessments of efficiency of pro-innovation efforts remained unchanged between 2005 and 2010. Next, rankings of countries according to IUS/EIS methodology are statistically similar to rankings of countries based on output/input ratio both for 2005 and 2010. However, this is not true when DEA-efficiencies for 2005 results are confronted with 2010 DEA-efficiencies results. To be noted, EISI 2005 is based on 26 indicators; IUSI 2010 on 24 indicators; whereas 8 are the same (almost the same) and 5 are similar. The remaining ones cannot be compared of one another. Thus, in fact, somewhat different interpretations of
innovativeness had been used. At this point it is not clear whether the change in efficiency between 2005 and 2010 resulted from the shift in interpretation of what innovations is (as has occurred in IUS/EIS reports), or whether innovation policies in the examined countries caused the change in efficiency. Further examination is needed in order to explain this change.

Above average efficiency tend to be characteristic of countries that score very high or very low in EISI (and correlation coefficients are, not surprisingly, very low in these areas). Thus, either a country wisely and heavily invests in innovations which make innovation efforts effective, or the country invest very little in inventions/innovations, yet as a side effect, it may report some efficiency related achievements. Concurrently, it is easier to be efficient if one can benefit from economies o scale, and does not fall into a trap of over-investment (congestion). This statement should be accepted as a preposition that calls for further examination.

Efficiency of innovations tend to be positively correlated with RS (return to scale) and with CON (congestion), both for 2005 and for 2010, and irrespective whether traditional (output/input measure), or non-parametric (DEA) interpretation of efficiency is used. This may indicate that RS (size in short), and CON (over/under-investment in short) may be decisive to efficiency of innovations. As an implication, one may suggest for small economies to concentrate on some types of innovations (areas of specialization) (then, they will achieve economies of scale), and for rich countries to seek opportunities to carry out inventive/innovative projects in locations where costs can be reduced (e.g., in new EU countries). This suggestion might have already been used by some companies which moved their engineering/research activities to countries with access to expertise at lower costs (e.g., Kogut and Zandar, 1993).

5. Concluding comments and suggestions for further studies

Results of this study suggest that there had been a change in efficiency measures of innovation approaches. However, it is not the case that countries radically and frequently change their "pro-innovation" policies, so that values of indicators of innovativeness change. Under the circumstances, the IUSI/EISI composition, as a "policy guide", becomes highly questionable. It may produce beneficial results when we examine why leaders in terms of input-to / output-from innovation are frequently technically not effective. For small countries there may be a permanent problem with achieving optimal Return to Scale because of lack of economies of scale and associated synergies. In other cases, problems with congestion may result from a lack of clearly identified patterns of specialization, poor coordination between government supported research institutions and business, inefficient commercialization of inventions, and inadequate transfer of knowledge between various agents involved in pro-innovative activities. Such conclusions, however, call for a more detailed examination, and in particular, detailed assessment of mechanisms embedded in NIS of countries.

	Table 2	*Results of DEA analysis for '05 AND '10*													
	DEA results for 2005									DEA results for 2010					
	EFF	RS	CON	PTE	EISI	efx5		CON		IUSI	efx10	EFF	RS	CON	PTE
	0,68	0,98	1,00	0,69	0,51	0,43	DRS	BE	DRS	0,52	0,50	0,79	0,97	0,82	1,00
	0,62	0,62	1,00	1,00	0,37	0,22	irs	BG	irs	0,17	0,41	0,75	0,75	1,00	1,00
	0,72	0,87	0,82	1,00	0,33	0,39	DRS	CZ	CRS	0,35	0,64	1,00	1,00	1,00	1,00
	0,89	0,89	1,00	1,00	0,39	0,56	irs	DK	CRS	0,63	0,57	1,00	1,00	1,00	1,00
	1,00	1,00	1,00	1,00	0,43	0,69	CRS	DE	CRS	0,61	0,81	1,00	1,00	1,00	1,00
	0,33	0,64	0,87	0,59	0,41	0,20	DRS	EE	DRS	0,41	0,46	0,80	0,98	0,81	1,00
	1,00	1,00	1,00	1,00	0,40	0,50	CRS	IE	DRS	0,46	0,54	0,64	1,00	0,64	1,00
	0,29	0,42	0,69	1,00	0,38	0,19	DRS	GR	CRS	0,31	0,77	1,00	1,00	1,00	1,00
	0,52	0,66	0,96	0,82	0,37	0,29	DRS	ES	DRS	0,30	0,55	0,96	0,96	1,00	1,00
	0,87	0,91	0,95	1,00	0,38	0,51	DRS	FR	DRS	0,45	0,48	0,67	0,95	0,71	1,00
	0,92	0,98	0,93	1,00	0,37	0,51	DRS	IT	CRS	0,34	0,80	1,00	1,00	1,00	1,00
	0,15	0,29	0,53	1,00	0,36	0,11	DRS	CY	CRS	0,42	0,63	1,00	1,00	1,00	1,00
	0,20	0,28	0,72	1,00	0,35	0,11	DRS	LV	CRS	0,15	0,42	1,00	1,00	1,00	1,00
	0,37	0,56	0,66	1,00	0,35	0,20	DRS	LT	DRS	0,21	0,26	0,76	0,76	1,00	1,00
	1,00	1,00	1,00	1,00	0,35	0,86	CRS	LU	CRS	0,50	0,76	1,00	1,00	1,00	1,00
	0,58	0,79	0,73	1,00	0,35	0,31	DRS	HU	DRS	0,23	0,60	0,92	0,93	0,99	1,00
	1,00	1,00	1,00	1,00	0,34	0,86	CRS	MT	CRS	0,25	1,76	1,00	1,00	1,00	1,00
	1,00	1,00	1,00	1,00	0,35	0,49	CRS	NL	CRS	0,48	0,48	1,00	1,00	1,00	1,00
	0,71	0,99	0,99	0,72	0,35	0,49	DRS	AT	DRS	0,50	0,63	0,98	0,99	0,99	1,00
	0,44	0,64	1,00	0,69	0,35	0,27	DRS	PL	DRS	0,23	0,40	0,68	0,79	0,86	1,00
	0,51	0,83	0,61	1,00	0,35	0,40	DRS	PT	CRS	0,38	0,67	1,00	1,00	1,00	1,00
	0,62	0,62	1,00	1,00	0,34	0,41	irs	RO	CRS	0,18	0,53	1,00	1,00	1,00	1,00
	0,66	0,86	0,76	1,00	0,34	0,30	DRS	SI	DRS	0,38	0,55	0,70	0,99	0,98	0,72
	1,00	1,00	1,00	1,00	0,33	0,64	CRS	SK	CRS	0,20	0,63	1,00	1,00	1,00	1,00
	0,89	0,92	0,97	1,00	0,35	0,53	DRS	FI	DRS	0,61	0,47	0,67	0,88	0,77	1,00
	0,83	0,92	0,91	1,00	0,36	0,55	DRS	SE	DRS	0,67	0,48	0,77	0,86	0,90	1,00
	0,84	0,90	0,94	1,00	0,36	0,48	DRS	UK	DRS	0,55	0,33	0,40	0,93	0,44	1,00
	0,42	0,81	1,00	0,51	0,37	0,28	DRS	IS	irs	0,32	0,28	0,58	0,58	1,00	1,00
	0,52	0,83	0,62	1,00	0,37	0,31	DRS	NO	irs	0,40	0,30	0,67	0,67	1,00	1,00
	0,90	0,90	1,00	1,00	0,38	0,67	irs	CH	CRS	0,78	0,70	1,00	1,00	1,00	1,00
ALL	**0,60**	**0,78**	**0,83**	**0,91**	**0,36**	**0,42**		**ALL**		**0,40**	**0,58**	**0,86**	**0,93**	**0,93**	**0,99**
CRS	0,89	0,93	0,95	1,00	0,36	0,60		CRS		0,39	0,69	0,98	0,98	1,00	1,00
IRS	0,76	0,76	1,00	1,00	0,37	0,46		IRS		0,30	0,33	0,66	0,66	1,00	1,00
DRS	0,55	0,71	0,81	0,84	0,35	0,32		DRS		0,42	0,48	0,75	0,92	0,84	0,98

(1) RSD=direction of the RS technology, increasing (IRS), decreasing (DRS) or constant (CRS), under which the various countries operate.

(2) Country "ALL" represents a country with inputs and outputs being the average of all the corresponding inputs and outputs of all countries in the database. Similarly, ALL, CRS, ALL DRS and ALL IRS, each represents a country with inputs and outputs being the average of the corresponding inputs and outputs of the CRS, DRS and IRS countries, respectively.

It is at times accepted that composite indexes may serve as a policy setting mechanism (that is also one of the objectives if the IUS/EIS approach. However, recommended innovation policies should not be considered as "an average" of responses from different sectors, by companies of different size, which operate within very different economic, political, and social context. An assumption that – "indicators have policy implications" – is difficult to endorse. Presented observations suggest that countries should adopt different innovation policies. This remark points out to yet another topic worth exploration. This topic deals with elimination of the impact of contextual variables (market factors, culture, accumulated stock of experience, macro-economic structure of the country, developed business links, etc.) upon efficiency of innovation systems. If the impact of contextual elements upon the level of innovativeness is isolated, a composite index could serve as a starting point to examine the effectiveness of programs oriented on support of innovativeness (i.e., to which extent policies related to innovativeness indeed contribute to social and economic objectives).

Moreover, data series used in IUS/EIS approach change frequently. Such a practice limits the possibility of identifying whether policy changes have contributed to the improvement of desired operational outcomes, and longitudinal type studies are limited. Consequently, the power of indexes as a tool that sets direction for policy formulation is substantially decreased.

One of the main trusts of the IUS/EIS approach is that indicators included to create an innovativeness index, can be impacted by means or regulations and national innovation policies. The subsequent IUS/EIS reports, and thus the selection of innovation indicators, seem to follow recommendations of Aho Report that suggests **"**a 4-pronged strategy focusing on the creation of innovation friendly markets, on strengthening R&D resources**,** on increasing structural mobility as well as fostering a culture which celebrates innovation". In such a manner, there should be somewhat of a departure from an emphasis on innovation inputs (such as R&D expenditures, hence inventions), and innovation outputs (such as patents, again an indicator of inventions), more in the direction of capturing aspects related to creation of demand for innovation, and socio-cultural, education, entrepreneurial, and flexible stimulators for implementation of innovations. However, the 2010 version of IUS (IUS, 2011) introduces such indicators as: (1.2.3.) Non-EU doctorate students, or (2.3.2.) PCT patent applications in societal challenges, which are oriented on inventiveness rather than innovativeness, not to mention, that they may favor vibrant research centers.

Results of a literature overview about innovativeness and the indexes used to measure it (e.g., Nasierowski, 2008), suggest a substantial overlap and redundancy of items used to assess the level of innovativeness of countries. Each composite index consists of sub-indexes, where all items are equally weighted: thus, the specificity of the context of operations in countries is not taken into account. Such methodology may be challenged for correctness in terms of arbitrary selecting (and grouping) indicators: numbers should indicate the number and nature of the factors that describe the idea. Moreover, several items are highly correlated – they carry the same information with regard to statistical significance of results (and country rankings). Each studied index captures some information related to economic improvement. Since these items are correlated, it should be asked which ones act as stimuli for the development of other ideas. This methodology, in principle, is characteristic of all composite indexes examined. Similarly, IUS/ EIS give equal weight to each factor, thereby having the average of the factor loadings as the overall country measure from which to obtain the ranks. One of the problems of equal weight approach is the lack of evidence that each item is equally important in the rankings. EIS (2005, p. 8) recognizes this problem and attempts different weighing schemes ("budget allocation, factor analysis, benefit of the doubt and equal weighting") and a Robustness Analysis, to no avail, i.e., with no statistically significant differences detected. A possible solution to this problem is to weigh each factor by the percentage of the total variance explained by the said factor. Moreover, recommended innovation policies should not be considered as "an average" of responses from different sectors, by companies of different size, which operate within very different economic, political, and social contexts, thus making one of objectives of the IUS/EIS approach – "that indicators have policy implications" - difficult to endorse. It is important that aspects of efficiency are addressed in a way, that permits a better modeling of EU policies, to the sectorial and regional specificity.

Conclusions from the IUS/EIS reports present only one of many aspects of assessment of innovative attempts of countries, namely their ranking as leading countries, average performance, catching up, and losing ground. Such ranking does not take specific economic and social conditions of the country into account, and emphasizes quantitative dimension of the issue – "the more inputs the outputs may be expected". However, it is equally important to know whether or not funds available are spent efficiently. This paper has attempted to offer insight into whether available funds are spent efficiently by countries, rather than focusing solely on the aforementioned classifications and rankings. The use of non-parametric techniques can essentially reformulate well established opinions and accepted levels of understanding the problems of innovativeness – not only what, but also an explanation of why?

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